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# Irrigation of Sugar Beets Grown for Seed [1]

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## INTRODUCTION

Sugar-beet seed growing is a relatively young industry in America. Early attempts to establish domestic production of sugar-beet seed by the United States Department of Agriculture in the 1890–1900 period and later attempts by agricultural experiment stations and the Department did not successfully withstand competition from European producers of sugar-beet seed. During World War I, in order to meet the emergency brought about by blockade of continental European ports, the beet-sugar industry grew large acreages of sugar beets for seed, and this effort continued a few years after the close of the war. The conventional European method, namely, production of seed from mother beet roots (stecklings) grown in one season, which were held over winter in pits or silos and then replanted in the seed field, was followed. Seed production in 1920 amounted to 6,770,000 pounds, grown on about 8,000 acres. With resumption of trade after the war, growing of sugar-beet seed was practically discontinued except for an annual production on about 500 acres in Colorado.

In the last decade, with the introduction of curly top resistant varieties and other adapted sorts, sugar-beet seed production was again started and has rapidly advanced. The domestic sugar-beet seed enterprises are located in Arizona, California, New Mexico, Utah, Nevada, Oregon, Washington, and Colorado, with limited production in other Western States. The field overwintering method is chiefly used. In 1941, 10,235 acres were grown, producing a total of 18,085,000 pounds of seed, a quantity slightly larger than the present annual requirements for planting the sugar-beet crop. Most of the practices now followed have been developed since the first curly top

[1] Conducted in cooperation with the Division of Agricultural Engineering, California Agricultural Experiment Station.



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resistant variety was made available by the United States Department of Agriculture in 1931. Earlier cooperative work [2] by the New Mexico Agricultural Experiment Station and the United States Department of Agriculture in New Mexico had laid the foundation for seed growing by discovering a method of successfully overwintering the plants in the field. In this method the seed is sown in late summer or early autumn and the plants are allowed to grow unthinned through the winter and, without transplanting, to produce seed the following spring.

Sugar-beet seed growing was established in southern California and southern Utah, as well as in New Mexico, when curly top resistant varieties became available. The rainfall in all of the areas where seed growing was first started is inadequate for such crops as the sugar beet, and the deficit must be made up by water supplied artificially. Under the most favorable circumstances irrigation is an expensive operation, and, therefore, irrigation experiments were promptly included in the program of sugar-beet studies carried on in the Hemet Valley of California by the United States Department of Agriculture. When seed growing was first started there, the irrigation practice followed was guided by earlier studies of Overpeck and Elcock [3] in New Mexico and involved very frequent irrigation during the blooming period.

## EARLY EXPERIMENTS

Irrigation experiments were started in the spring of 1933 and continued during the next two seasons. The experimental field was given uniform irrigation until the first of May; then it was divided into sets of plots, each set including six replications. Two irrigation intervals were used—7 and 14 days. Approximately the same total amount of water was applied in both instances. When the plots were harvested the first season, there was no significant difference in germination or yield of seed between the treatments.

The experiment was repeated in 1934 with the difference that just prior to the beginning of the differential irrigations, owing to uncontrollable circumstances, the whole field was not heavily irrigated as in the preceding season. In this second year there was a small but significant difference in yield and germination in favor of the plots that were irrigated every 7 days.

A third trial was conducted in the spring of 1935. In this case, a final, uniform, heavy irrigation was given in early spring, as in the season of 1933. The irrigation intervals used in this test were 4, 7, and 14 days. Results of this third year's test showed no significant differences among the treatments, thus agreeing with the 1933 experiment.

The results of the 3 years' work indicated that the frequency of irrigation did not affect the quality or quantity of the seed produced, provided the soil was thoroughly wetted before the treatments began. Because the moisture penetration had not been studied and the amount of water lost by run-off was not measured, it seemed advisable, however, to repeat the tests under better controlled conditions.

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[2] OVERPECK, JOHN C. SEED PRODUCTION FROM SUGAR BEETS OVERWINTERED IN THE FIELD. U.S. Dept. Agr. Cir. 20, 8 pp., illus. 1928.

[3] OVERPECK, JOHN C., and ELCOCK, HARRY A. METHODS OF SEED PRODUCTION FROM SUGAR BEETS OVERWINTERED IN THE FIEID. U. S. Dept. Agr. Cir. 153, 22 pp., illus. 1931.

## METHODS

In the spring of 1938 an experiment was conducted in cooperation with the Division of Irrigation, University of California. The experimental field, which had been leveled and planted the preceding fall, was divided by levees into 18 plots, each 8 rows wide and 80 feet long. The plots were uniformly irrigated until the first part of May. After that, one series was irrigated every week, a second every 2 weeks, and a third every 3 weeks. These series were designated as 1, 2, and 3, respectively. The plan of the experiment was to apply to the plots irrigated on the 2- and 3- week schedule, two and three times as much water at an irrigation as applied to those in the 1-week series.

Along the length of the plots in the 1938 test, there was a slope in the ground surface of about 6 inches. This differential in elevation made it difficult to make uniform applications of water, particularly in the plots in which irrigation water was applied at 2- and 3-week intervals. The lower ends of these plots received the major part of the water, and, because of the difficulty described, the plots in series 2 and 3 received less water than those in series 1.

In harvesting the seed crop, the upper and lower ends of the plots were harvested separately. Because the yields from the upper and lower sections did not differ significantly, whole-plot yields are reported (see table 5).

Soil-moisture studies were conducted throughout the duration of the experiment. Moisture-equivalent values and permanent wilting percentages of the soil were determined by laboratory tests.[4]

In the spring of 1939 the experiment was repeated, but with better controlled conditions. Prior to planting, the plots were leveled longitudinally, thus avoiding the difficulty of the ununiform distribution of water in the previous year. Plots in series 1 and 2 received about the same total amount of water. Plots in series 3 would have received approximately the same amount, but the seed was harvested a few days before the time at which the final irrigation normally would have been applied. Therefore, the total amount of water applied to plots in series 3 was less than to those in series 1 and 2.

During the period May 15 to June 26, morning and afternoon readings of relative humidity were made with a psychrometer in the first plot of each series and in an adjacent open field.

## RESULTS, 1938–1939

The dates of application of irrigation water and the quantity applied during the trial periods for both 1938 and 1939 are shown in table 1.

[4] "Moisture equivalent is the moisture content of a soil sample three-eighths inch deep when subjected to gravitation pull of the earth magnified 1,000 times by means of a centrifuge. The moisture equivalent is approximately equal to field capacity for most soils except the coarsest and some of the finest.

"Evaporation and plant transpiration finally reduce the moisture content to so low a value that plants growing in the soil wilt and cannot revive except by watering. The moisture condition of the soil at this state is known as the permanent wilting percentage or wilting coefficient."

Quoted from T. D. Rice and L. T. Alexander. The physical nature of soil. U. S. D. A. Yearbook 1938: 887–896.

TABLE 1.—*Dates of application of irrigation water and quantity applied for the years 1938–1939*

| Date of application | Quantity of water applied to plots in series— | | | Date of application | Quantity of water applied to plots in series— | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | | 1 | 2 | 3 |
| 1938 | *Inches* | *Inches* | *Inches* | 1939 | *Inches* | *Inches* | *Inches* |
| April 25 | 2.7 | 3.2 | 2.9 | May 3 | 2.0 | 1.5 | 1.8 |
| May 4 | 1.7 | ------- | ------- | May 8 | 2.2 | 4.2 | ------- |
| May 9 | 1.3 | 1.3 | ------- | May 15 | 1.5 | ------- | 5.0 |
| May 16 | 2.3 | ------- | 2.3 | May 22 | 1.8 | 3.3 | ------- |
| May 23 | 1.8 | 1.8 | ------- | May 29 | 1.7 | ------- | ------- |
| May 31 | 2.1 | ------- | ------- | June 5 | 1.7 | 3.3 | 5.0 |
| June 6 | 2.9 | 3.0 | 3.1 | June 15 | 1.8 | ------- | ------- |
| June 15 | 2.3 | ------- | ------- | June 19 | 1.7 | 3.3 | ------- |
| June 22 | 1.8 | 2.6 | ------- | | | | |
| Total | 18.9 | 11.9 | 8.3 | Total | 14.4 | 15.6 | 11.8 |

In table 2 the values from soil-moisture studies are reported for plots in series 2 and 3. The results show that the plants removed water from the soil to a depth of at least 4 feet.

TABLE 2.—*Average soil-moisture percentage for plots in series 2 and 3*

| Year and depth sampled (feet) | Soil moisture for plots in series 2 on dates indicated— | | | | | | | | | Soil moisture for plots in series 3 on dates indicated— | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | April 4 | April 23 | May 5 | May 7 | May 12 | May 20 | May 27 | June 8 | June 9 | April 4 | April 23 | May 2 | May 14 | May 20 | June 4 | June 9 |
| 1938 | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 0–2 | 15.0 | 9.2 | 13.5 | 11.2 | 11.5 | 9.2 | 10.9 | 7.5 | 11.3 | 14.1 | 9.4 | 13.8 | 8.7 | 15.5 | 6.9 | 13.6 |
| 2–4 | 9.3 | 8.4 | 8.8 | 8.9 | 8.3 | 8.0 | 7.4 | 7.3 | 6.8 | 9.2 | 8.6 | 8.8 | 8.4 | 9.8 | 6.6 | 7.1 |
| 4–6 | 7.4 | 6.6 | 6.7 | 6.4 | 6.2 | 5.8 | 5.2 | 5.6 | 5.6 | 8.1 | 7.5 | 6.3 | 6.3 | 7.2 | 6.3 | 5.7 |
| 6–8 | 12.1 | 11.7 | 12.6 | 12.8 | 12.7 | 13.0 | 12.8 | 11.6 | 11.5 | 12.5 | 12.1 | 12.7 | 12.6 | 13.7 | 12.0 | 11.2 |

| Year and depth sampled (feet) | Soil moisture for plots in series 2 on dates indicated— | | | | | | | | Soil moisture for plots in series 3 on dates indicated— | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | May 6 | May 11 | May 19 | May 26 | June 2 | June 8 | June 15 | June 23 | May 13 | May 20 | June 2 | June 10 | June 21 |
| 1939 | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 0–1 | 14.1 | 16.9 | 13.0 | 15.3 | 10.9 | 15.7 | 9.8 | 14.8 | 10.6 | 15.9 | 7.5 | 15.5 | 8.1 |
| 1–2 | 13.3 | 16.5 | 15.1 | 16.1 | 14.7 | 14.1 | 13.5 | 14.5 | 11.6 | 16.9 | 10.5 | 15.5 | 10.0 |
| 2–3 | 15.7 | 19.3 | 20.0 | 21.0 | 18.9 | 16.5 | 17.5 | 16.8 | 16.7 | 21.5 | 15.4 | 20.8 | 16.5 |
| 3–4 | 14.4 | 15.2 | 16.9 | 17.0 | 17.2 | 16.1 | 15.6 | 15.3 | 14.4 | 16.3 | 14.5 | 15.7 | 14.4 |
| 4–6 | 18.1 | 18.3 | 19.6 | 19.8 | 19.2 | 18.8 | 17.5 | 19.0 | 18.7 | 18.7 | 17.6 | 18.2 | 17.4 |
| 6–8 | 15.8 | 15.4 | 15.3 | 15.8 | 16.5 | 16.4 | 16.0 | 16.6 | 15.9 | 15.8 | 16.3 | 16.0 | 15.7 |

Table 3 presents the average moisture equivalents and average permanent wilting percentages of soil samples taken at 1-foot increments to a depth of 4 feet in the 1938 test plots. These results show that throughout the period of differential irrigation treatments the average soil moisture in the upper 4 feet of soil was above the wilting percentage.

TABLE 3.—*Average moisture equivalents and average permanent wilting percentages of soil samples taken at foot increments to a depth of 4 feet, 1938*

| Plots in series No.— | Moisture equivalent at— | | | | Permanent wilting percentage at— | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 foot | 2 feet | 3 feet | 4 feet | 1 foot | 2 feet | 3 feet | 4 feet |
| 1 | 14.9 | 16.3 | 14.2 | 11.6 | 6.0 | 6.7 | 5.9 | 4.9 |
| 2 | 15.7 | 18.3 | 14.3 | 11.5 | 6.4 | 7.0 | 5.7 | 4.8 |
| 3 | 15.1 | 18.3 | 15.4 | 12.9 | 6.1 | 7.4 | 6.2 | 5.3 |
| Average | 15.2 | 17.6 | 14.6 | 12.0 | 6.2 | 7.0 | 5.9 | 5.0 |

During the period May 15 to June 26, morning and afternoon readings of relative humidity were made with a psychrometer in the first plot of each series and over adjacent open land. The results presented in table 4 show that the humidity of the atmosphere immediately adjacent to the sugar beets was practically the same in all treatments.

TABLE 4.—*Relative humidity of atmosphere near top of seedstalks in plots of series 1, 2, and 3, and over bare land, May 15–June 26, 1939*

| Time of reading | Relative humidity in plots [1] of series— | | | Relative humidity over bare land |
|---|---|---|---|---|
| | 1 | 2 | 3 | |
| A. M | 62.6 | 62.1 | 62.3 | 54.0 |
| P. M | 47.6 | 48.1 | 48.3 | 42.4 |
| Average | 55.1 | 55.1 | 55.3 | 48.2 |

[1] 37 observations for each plot 2 times daily.

The seed yields and germination for the 1938 and 1939 tests are presented in table 5. These results show that where the soil moisture was supplied in adequate amount the yields were practically the same, regardless of the frequency with which water was applied.

TABLE 5.—*Results obtained with sugar beets grown for seed from irrigations at 1-, 2-, and 3-week intervals: Tests using plots 8 rows wide and 80 feet long, replicated 6 times; at Hemet, Calif., in 1938 and 1939* [1]

[Results given as 6-plot averages]

| Intervals between irrigations | 1938 [2] | | | 1939 [3] | | |
|---|---|---|---|---|---|---|
| | Acre yield of clean seed | Seed-ball germination (14 days) | Net acre yield of viable seed | Acre yield of clean seed | Seed-ball germination (14 days) | Net acre yield of viable seed |
| | *Pounds* | *Percent* | *Pounds* | *Pounds* | *Percent* | *Pounds* |
| 1-week | 3,539 | 95 | 3,362 | 3,088 | 82 | 2,532 |
| 2-week | 3,288 | 92 | 3,025 | 3,094 | 79 | 2,444 |
| 3-week | 3,454 | 93 | 3,212 | 3,093 | 80 | 2,474 |
| Difference required for significance (19:1) | 289 | 8.5 | ---------- | 149 | 5.6 | ---------- |

[1] 4 center rows harvested for yield data.
[2] Planted Sept. 7, 1937; harvested June 27, 1938.
[3] Planted Aug. 29, 1938; harvested June 27, 1939.

## DISCUSSION AND CONCLUSIONS

The results show that the moisture content in all of the treatments was maintained above the permanent wilting percentage in each 2-foot increment at all times. The relative humidity of the air was the same in all irrigation treatments and distinctly higher than in the adjacent open field. The humidity of the atmosphere immediately adjacent to the seedstalks was continuously at a high level, regardless of frequency of irrigation. The seed yield showed that where adequate amounts of soil moisture were maintained the yields were practically the same, regardless of the frequency with which the irrigation water was applied.

The same was found to be true with regard to germination. The practice by some sugar-beet seed growers of applying irrigation water at frequent intervals so that water is standing in the furrows nearly constantly during the flowering period is a waste of water, and actual damage to the crop may result.

However, the fact is recognized that the art of irrigating sugar beets for seed cannot be immediately mastered by every new sugar-beet seed grower and that, in general, it is safer to be a little extravagant with irrigation rather than to allow the plants to suffer from lack of water. In areas where frequent irrigations are the practice, economies can be effected by lengthening the intervals between irrigations, provided adequate water is applied at each irrigation.

## SUMMARY

Studies on irrigation of sugar beets grown for seed in the Hemet Valley of California during five seasons have revealed that, if adequate moisture is supplied during the blooming period, irrigation at 7-day intervals gave no better results, as measured by yield and percentage of seed germinating, than irrigations at 14- and 21-day intervals.

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